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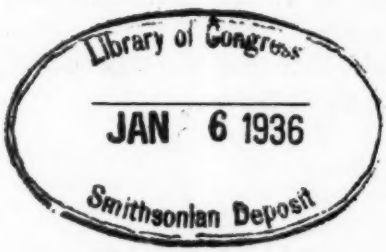
AMERICAN PHYSICAL SOCIETY



PROGRAM

FOR THE

BALTIMORE MEETING

NOVEMBER 29–30, 1935

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

The American Physical Society

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BALTIMORE MEETING, NOVEMBER 29–30, 1935

THE 201st regular meeting of the American Physical Society will be held at The Johns Hopkins University, Baltimore, Maryland, on Friday and Saturday, November 29 and 30, 1935.

On Friday afternoon, November 29, R. W. Wood will give a talk on the ruling engines as an introduction to the showing of the ruling engines and a trip through the laboratories.

Luncheon. Luncheon can be had in the dining rooms of apartment houses in the immediate neighborhood of the campus.

Dinner. On Friday evening at seven o'clock there will be a dinner for the members of the American Physical Society and their friends at the Baltimore Country Club. The Club can be reached by car 29 northbound; ride to Club Road and Roland Avenue and walk one block west. The price of this dinner is $1.50 per plate. Tickets should be purchased at the Chemistry Building at the session on Friday morning.

GENERAL INFORMATION

Headquarters. The headquarters hotel is the Belvedere Hotel, Charles and Chase Streets, where the rates are $3.50 for single rooms and $5.00 to $6.00 for double rooms, all with bath. Rooms may be had for men only at the Knights of Columbus Club, Cathedral and Madison Streets, rooms with running water for $1.50 single, $2.50 double; with showers, $2.50 single, $4.00 double. Some double rooms at $3.00 per day may be had in apartment houses in the neighborhood of the University. For the latter, reservations should be made not later than November 22 by writing to Dr. K. F. Herzfeld. For other rooms members are urged to make their reservations at once, writing directly to the hotel.

Transportation in Baltimore. Transportation from railroad stations: From the Pennsylvania Station to the University take street car 29 or bus northbound; to the Hotel Belvedere take bus or any street car southbound; to the Knights of Columbus Club take bus southbound to Madison Street and walk one block west, or any street car southbound to Read Street and walk one block south and one block west. From the Baltimore & Ohio, Mount Royal Station, walk three blocks east to Charles Street; for the University take a bus marked "A, University Parkway," north, or a street car 29 north; to the Hotel Belvedere, same directions as for the Pennsylvania Station. From Camden Station to the University take street car 17 and ask for a transfer to 29; to Hotel Belvedere street car 17; to the Knights of Columbus Club take car 27 to Park Avenue and Madison and walk one block east.

From the Belvedere Hotel to the University take street car 29 or bus marked "A, University Parkway," north; from the Knights of Columbus Club walk one block west to Charles Street to take bus as from the Belvedere Hotel; or walk one block west and one block north to take a street car as from the Belvedere Hotel.

Railroad Rates. The Society has made no arrangements for special rates to this meeting. Members should get in touch with their local ticket agents regarding possible reduced Thanksgiving rates.

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.) Papers received after the program has been printed will be placed in the supplementary program.

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Editorial Secretary, The American Institute of Physics Incorporated, 11 East 38th Street, New York, N. Y.

St. Louis Meeting. The preliminary arrangements of the St. Louis program include a joint session on Tuesday, December 31, with the American Association of Physics Teachers in a symposium on "Photoelectricity," and a joint session on Wednesday, January 1, with Section B of the American Association for the Advancement of Science and the American Association of Physics Teachers at which time the Retiring Vice President of Section B, Henry G. Gale, will deliver an address on "The Diffraction Grating." There will also be addresses by the President of the American Physical Society, R. W. Wood, and by Arthur H. Compton on "Recent Developments in Cosmic Rays." The Josiah Willard Gibbs Lecture will be delivered by Vannevar Bush on "Mechanical Analysis." The dinner will be held on Tuesday evening, December 31.

Other meetings for the current season are as follows:

202. December 20–21, 1935. Berkeley, California.
203. December 31, 1935–January 2, 1936. Annual Meeting. St. Louis, Missouri.
204. February, 1936. New York City.
205. April, 1936. Washington, D. C.

W. L. Severinghaus, *Secretary*
Columbia University, New York, N. Y.

November 12, 1935.

CALENDAR

Friday Morning, November 29

10:00 o'clock: Chemistry Building: Room 1: Papers 1–10.

10:15 o'clock: Remsen Hall: Room 219: Meeting of the Council.

Friday Afternoon, November 29

2:00 o'clock: Chemistry Building: Room 1: Papers 11–18.

4:00 o'clock: Chemistry Building: Room 1: Talk by R. W. Wood and visit through laboratories.

7:00 o'clock: Baltimore Country Club: Dinner.

Saturday Morning, November 30

10:00 o'clock: Chemistry Building: Room 1: Papers 19–27.

Saturday Afternoon, November 30

2:00 o'clock: Chemistry Building: Room 1: Papers 28–35.

PROGRAM

FRIDAY MORNING AT 10:00 O'CLOCK

Chemistry Building, Room 1

Paper No. 1 will be read by title.

1. Gyroscopes and Tops with Bearings.* R. C. COLWELL AND N. I. HALL, *West Virginia University.*—In the usual form of the gyroscopic top, the gyroscope is attached to a rod and is balanced by a weight adjusted along the rod. The support of this rod is rotatable about a horizontal and vertical axis. If the rod is placed in a bearing at the point of support, the gyroscope is given another degree of freedom and some very interesting motions may be produced. A new type of top has been developed consisting of a copper disk two inches in diameter and one inch high. This disk is fixed to a one-foot copper rod by means of a high speed bearing. The top is revolved 35,000 r.p.m. in the rotating field of an Alexanderson alternator. This tall top will stand vertically at first and will finally precess in an almost horizontal position.

* To be read by title.

2. Effect of Deuterium Oxide on Action of Some Enzymes. DAVID I. MACHT, *The Pharmacological Research Laboratory, Hynson, Westcott & Dunning, Inc., Baltimore. (Introduced by A. H. Pfund.)*—Ever since the discovery of heavy water much speculation of very diverse character has been advanced in regard to its possible effects on life. The most extreme views are presented by those who claim, without experimental proof, that deuterium oxide is a most powerful, destructive physiological agent and those who, basing their conclusions on experiments made with deuterium oxide in dilute concentrations, state that its pharmacological effects are of negligible character.[1] The author has recently discovered an interesting and striking contrast in the biophysical and biochemical behavior of H_2O and D_2O, which consists of a difference in velocity of reaction shown by certain animal and vegetable enzymes suspended in them. Studies were made on the behavior of muscle oxydase from the rat and on the reductase of finely ground seeds of Lupinus albus by the Thunberg method of determining the rapidity with which a standard buffered solution of methylene blue is decolorized. A marked difference was found to exist between identical enzymes suspended in H_2O and D_2O, respectively. This difference can be demonstrated not only with concentrations of D_2O, 1 : 100, but also with much *weaker* concentrations. Further studies regarding the activity of another enzyme, catalase, also revealed a difference in the speed of reactions as determined by H_2O and D_2O, respectively.

[1] Cf. Macht and Davis, "Some Pharmacological Experiments with Deuterium," J. Am. Chem. Soc. **56**, 246 (1934).

3. Ratio of Specific Heats of Air, N_2, and CO_2 as a Function of Pressure, by the Ultrasonic Method. J. C. HUBBARD AND A. H. HODGE, *The Johns Hopkins University.*—Measurements have been completed by Hodge of ultrasonic velocities at 27°C at pressures from 1 to 60 atmospheres for CO_2 and to 100 atmos. for air and N_2. The method used[1] permits the use of small scale apparatus and the driving of the source at any desired pressure. The results for CO_2 at a frequency of 88.39 kc, combined with the compressibility data of Amagat, give for γ at 27°C values from 1.304 at 1 atmos. to 3.524 at 60 atmos. The results for air at frequency 286.17 kc and for N_2 at 286.09 kc, combined with the respective compressibility data of Holborn and Otto, give at 27°C for air, values of γ between 1.408 at 1 m Hg and 1.584 at 80 m Hg, and for N_2, 1.402 at 1 m Hg to 1.572 at 80 m Hg. These and the other results between the limits quoted are in excellent general agreement with the few scattered results available for comparison, such results being very meager because of the technical difficulties of methods hitherto used for evaluating C_v or γ under even very moderate pressures.

[1] Hubbard, Phys. Rev. **46**, 525 (1934) *et ante.*

4. Deviations of Ortho- and Parahydrogen from the Laws of Ideal Solutions. F. G. BRICKWEDDE AND R. B. SCOTT, *National Bureau of Standards.*—An explanation of the vapor-pressure differences of *o*- and *p*-H_2 based on energy differences associated with intermolecular forces of orientation in the condensed states is suggested. These forces would be expected to differ for rotating and non-rotating varieties, and hence mixtures of these should show large deviations from ideal solution laws. Subsequent experimental data have confirmed this. Differences in vapor pressures of liquid mixtures containing 0, 19, 38, 57, 66, and 75 percent *o*-H_2 were measured from 14° to 20.4°K, and solid mixtures containing 0, 38, and 75 percent from 10.5° to 14°K; from these data differences in latent and specific heats were calculated. The size of the deviations is indicated by the table for liquid solutions at 20.4°K.

[*o*-H_2] CONC. OF *o*-H_2 IN SOL.	*$\Delta P(p-s)$ AT 20.4°K (mm Hg)	$\frac{\Delta P(p-s)}{[o\text{-}H_2]}$	$\frac{\Delta L(s-p)}{[o\text{-}H_2]}$
0.1889	4.26	22.6	1.97
.3796	10.36	27.3	2.54
.5658	17.86	31.6	3.02
.6573	22.16	33.7	3.27
.7500	26.80	35.7	3.49

* $\Delta P(p-s)$ is the difference between the vapor pressures of *p*-H_2 and the solution.

The nonproportionality of the anomalous specific heat below 10°K of solid solutions[1] of *o*- and *p*-H_2 to the *o*-H_2 concentration is accounted for.

[1] Simon, Mendelssohn and Ruhemann, Naturwiss. **18**, 34 (1930).

5. A Problem in Potential Theory. MORRIS MUSKAT, *Gulf Research & Development Corporation, Pittsburgh, Pa.*—Two methods have been developed for treating a new

type of potential problem arising in the study of the encroachment of water into an oil sand. The problem is that of finding the potential distributions in two regions of different "constants" ("conductivities"), separated by a movable surface of unknown shape, its motion and shape to be determined by the conditions that each point of the interface should have a velocity proportional to the vector gradient of the potential at the point, and that the area swept out by it shall assume the "constant" appropriate to that of its encroaching side. The first, a perturbation method, is valid when the difference between the "constants" is small, and reduces the problem of determining the shape and motion of the interface and the potential distributions *simultaneously*, to a series of problems in which potential distributions are to be found on the sides of *known* interfaces, and the motion of the surface is to be found in a *known* (time varying) potential field. This same type of reduction is effected also in the second method, which is one of direct successive approximations, but which may be used for any values of the potential "constants."

6. Residual Moisture in Cellulose Dielectrics. EUGENE W. GREENFIELD, *Yonkers, N. Y.*—This paper discusses in a brief way the chemical and colloidal nature of the structure of cellulose paper as elucidated by the rich background of cellulose research and the more modern physico-chemical studies into the subject. With these theories of structure and our modern ideas of adsorption, the mechanism by which moisture is taken up or eliminated by or from cable paper is discussed. Argument is advanced to demonstrate that practically all of the free water residing in well dried cable paper exists in an adsorbed state upon or between the capillary walls. From a study of the dielectric properties of a sample of cable paper taken over a range of evacuation pressures it was possible to determine the quantity of residual moisture retained by the paper and from this the thickness of the adsorbed moisture films. It is shown that over the drying range studied, the paper exhibits a typical adsorption isotherm the equation of which is derived. Based on the above conclusions, the mechanism of the electrical behavior of adsorbed ion systems is discussed with particular reference to explaining the anomalous behavior of "dry" cable paper.

7. Magnetic Inversion Points by the Diffusion of H_2 Through Nickel and Iron and Through Iron-Nickel and Palladium-Nickel Alloys. W. R. HAM AND J. D. SAUTER, *Pennsylvania State College.*—The diffusion of hydrogen through homogeneous metals follows the formula $R=A[(p_0{}^y-p_i{}^y)/X]Te^{-b/T}$, where R=rate of diffusion, A=a constant of the diffusing metal, p_0 and p_i=pressures on ingoing and outgoing sides, y=a variable exponent often nearly 0.5, T=temperature Kelvin, X=thickness of diffusing sheet, b=total work function expressed in equivalent degrees. Over a temperature range between 200° and 800°C the isotherms for the above metals are almost exactly linear between pressures of 74 cm and 1 cm of Hg, but the slopes (y) are not necessarily constant with temperature change, nor are the isobars necessarily linear. Pure nickel shows a discontinuity in diffusion isobars at 360°C which cannot be mistaken, as does also palladium slightly alloyed with nickel. The cooling curves and magnetometer curves for nickel show the magnetic inversion to be very nearly at this same point. In the case of iron alloyed with nickel, the isobars show a sharp change in slope around 600°, whereas pure iron shows a large change in its isobars beginning at 760°C. The energy changes involved in these magnetic transformations are discussed.

8. Recording Field Current Electrons with a Geiger-Müller Counter. R. T. K. MURRAY, *The Johns Hopkins University.*—Preparatory to an attempt to measure directly the temperature dependence of field current emission, single field current electrons have been recorded by means of a Geiger-Müller counter. The cathode consisted of a brass sphere placed in a vacuum over a plane anode containing a small hole covered by a thin aluminum window which looks into a counter. Steady negative potentials between 10 and 20 kv were applied to the sphere. Tests showed that no detectable x-ray quanta were produced and for electrons having energies over 10 kv the window was perfectly transparent within the limits of experimental error. The field at the surface of the sphere necessary to give a threshold defined by an average current of 1 electron per second varied from about 50,000 volts per cm for a polished sphere to 20,000 volts per cm for one artificially roughened with an abrasive. Linear log current against reciprocal field strength relations were obtained over a current range from 1 electron every 10 seconds to 30 electrons per second in accordance with the Fowler-Nordheim relation $i=ae^{-b/F}$. Calculations of the microscopic form factors of the points give values as high as 400 and average emitting areas as low as 10^{-22} cm^2.

9. Photoelectric Work Function of Barium. R. J. CASHMAN AND N. C. JAMISON, *Northwestern University.*—After repeated distillation in high vacuum, barium was deposited on a nearly plane glass surface. The photoelectric work function at room temperature was determined by Fowler's method. In order to obtain accurate values of absorbed energy the reflection coefficient of the surface was measured. It was found to vary from 44.7 to 47.9 percent in the range from 4189 to 5035A, the range used in obtaining Fowler plots. The reflection was measured also at −77°C and as predicted by theory no change from the room temperature value was obtained in the wave-length range investigated. The shift necessary to superimpose the experimental curves upon the theoretical curve due to Fowler could be determined definitely to less than one-tenth of one percent. Measurements made from two hours to three months after laying down different deposits yielded the value, 2.517 volts, for the work function. The authors do not maintain at present that the work function of pure Ba is 2.517 volts; the data suggest, however, that photoelectric work functions as measured by Fowler's method may be determined more accurately than those reported in the past. Thus far but one sample of barium has been used; work is in progress to obtain even more carefully purified samples of barium.

10. The Filter-Coupled Inductive Glow Discharge Oscillator. WINSTON E. KOCK, *The Institute for Advanced Study.*—The characteristics of an inductive glow discharge oscillator are reported whereby the previous control circuit of inductance and capacity is replaced by a control circuit comprising a multisection filter. The sharper resonance band thus presented effects a greater frequency stability by exerting a more effective control over the oscillations of the glow tube. Various types of filter sections are discussed and comparative curves given.

FRIDAY AFTERNOON AT 2:00 O'CLOCK

Chemistry Building, Room 1

Paper No. 11 will be read by title.

11. Influence of Physical Development in Region of Solarization.* ANNA JOYCE REARDON, *Saint Louis University. (Introduced by F. E. Poindexter.)*—In a previous paper entitled *Solarization at Low Intensity*[1] eight reversals in the region of solarization were established experimentally with chemical development. This same experiment was repeated by using three methods of physical development. The first, physical development before fixation as described by Odell;[2] the second, pre-fixing with acid hypo and then development of latent image in Odell's silver nitrate-amidol developer; and the third, pre-fixing of latent image in 30 percent plain hypo and development in Odell's developer. These three methods of physical development showed no reversal for extra fast, undyed, dry hammer plates. In each case there was a continuous increase in the density of the latent image. This shows that in the region of solarization there is no decrease in the amount of silver deposited by the light exposure and that the prolonged light action does not decrease the amount of silver which has already been deposited. Therefore when solarization of the latent image occurs it must be due to some other cause. We suggest the possible closing of the fissures in the emulsion as set forth in the crystal cracking hypothesis of the latent image.

* To be read by title.
[1] Reardon, J. O. S. A. **24**, 331 (1935).
[2] Odell, Ind. Eng. Chem. **25**, 877–879 (1933).

12. Spectra of Strontium Deuteride and Hydride. WILLIAM W. WATSON, *Yale University,* W. R. FREDRICKSON AND M. E. HOGAN, JR., *Syracuse University.*—Details of the B and C band systems of SrD and the D system of SrH are presented. For the normal $^2\Sigma$ state $B_e^* = 1.9427$ for SrD and 3.8788 for SrH. The ratio of these, 0.50635, shows about the expected departure from equality with the ratio $\rho^2 = 0.50603$ of the reduced masses. The spin doubling of the normal state of SrD is regular, $\gamma_0 = +0.0613$ being almost exactly in the ratio ρ^2 with the value for SrH. In contrast with the corresponding state of CaD, the spin doubling of the $B\ ^2\Sigma$ state of SrD departs markedly from the usual linear variation with $K+\frac{1}{2}$. The (0,0) C band of SrD exhibits multiple perturbations and a sharp cut-off of the branches at $K' = 29$. For the $C\ ^2\Sigma$ state $B_0 \leqq 1.95$, but exact analysis of this state is hindered by the lack of any unperturbed lines. Two bands $(v',2)$ and $(v',3)$, with a common upper state, of the $D\ ^2\Sigma \rightarrow N\ ^2\Sigma$ "many-lined" SrH system having R branch heads at 18,446.21 and 17,341.39, respectively, have been analyzed. In this D state, for which $B_v = 1.913$, large irregular perturbations occur. Finally, the nature of and the interactions among the known electronic states of the alkaline earth hydrides are discussed.

13. A Test of the Interval Rule in the $^2D_{3/2}$ State of Bi I. E. U. MINTZ AND L. P. GRANATH, *New York University, University Heights.*—The hyperfine structure of the line $\lambda 4722.5$ $(6p^3\ ^2D_{3/2} - 6p^2 7s(1)_{1/2})$ in the arc spectrum of bismuth was investigated using a Fabry-Perot etalon. The intervals between the six hyperfine structure components were measured and corrections were made for their mutual influence. A deviation from the Landé interval rule was found in the $^2D_{3/2}$ state. In the table under (a) and (b) are listed the measured intervals and those calculated from the Landé interval rule with a spin of 9/2 and the total measured separation of the $^2D_{3/2}$ state. The findings here are in accordance with those obtained for lines in europium and lutecium II by Schüler and Schmidt, and can be explained by the addition of a $\cos^2(ij)$ term to the usual cosine law of interaction. Under (c) in the table are the values of the intervals calculated letting $E = E_0 + a_1 \cos(ij) + a_2 \cos^2(ij)$. The constants $a_1(276.7)$ and $a_2(12.9)$ were calculated with the interval $f_{(6-5)}$ (258 $\times 10^{-3}\,\mathrm{cm}^{-1}$) and the total separation.

Measured and Calculated Intervals (in $\Delta\nu \times 10^{-3}$ cm^{-1}) for $^2D_{3/2}$ State of Bi I.

Δf	(a) Measured	(a) Interval factors	(b) Calculated from cos law	(c) Calculated from cos^2 law
$f_{(4-3)}$	148	37	162	149
$f_{(5-4)}$	200	40	202	199
$f_{(6-5)}$	258	43	243	258

14. The Excitation Function of Lithium under Proton Bombardment. M. OSTROFSKY, G. BREIT AND D. P. JOHNSON, *Institute for Advanced Study, Princeton, New Jersey.*—It is found that agreement with experiment for 8 cm alpha-particles can be obtained either by using the part of the incident wave having an angular momentum $L = 0$ or the part having $L = 1$. For the first condition with a radius of 0.35×10^{-12} cm one needs a "well" about 35 MEV deep. For $L = 1$ and the same radius a "well" about 21.5 MEV is needed. The saturation of the yield with

voltage is not a good measure of the height of the barrier and of the nuclear radius. The position of stationary and resonance levels is important for the shape of the excitation curve. The effect of the decay of the incident wave inside the nucleus is estimated and is found to be small in the present case. The "well" necessary for the representation of the alpha-particle reaction is compared with the mass of Be^8. It is found possible to fit this by attributing the alpha-particle reaction to $L=0$ and the formation of Be^8 from Li^7 to the addition of a proton into a p level.

15. Quantum-Mechanical Calculation of Energy of H_3 and H_3^+. J. HIRSCHFELDER, H. EYRING AND N. ROSEN, *Princeton University.*—The potential energy for all linear symmetrical nuclear configurations of the triatomic hydrogen molecule and ion has been calculated by the variational method with hydrogen-like $1s$ atomic orbitals by varying the screening constant and the amount of all polar and homopolar states in the eigenfunction. The lowest energies (in kcal./mole = 1/23.06 e.v.) and separations between neighboring atoms (in Bohr radii) are given in the table. The activation energy of the reaction

	$E_{H_3}-3E_H$	$(r_0)_{H_3}$	$E_{H_3^+}-2E_H-E_{H^+}$	$(r_0)_{H_3^+}$	$E_{H_2}-2E_H$	$(r_0)_{H_2}$
Heitler-London approx.	−53.11	2.00	−91.92	2.00	−72.18	1.65
H. L. plus ionic approx.	−60.39	2.00	−108.64	2.00	−74.02	1.70
Wang approx.	−56.16	1.89	−130.89	1.55	−86.94	1.38
Wang plus ionic approx.	−67.09	1.84	−155.35	1.52	−92.24	1.40
Experimental	−101				−108.6	1.40

$H+H_2 \rightarrow H_2+H$ is calculated to be 25.15 kcal., i.e., 18 kcal. greater than the experimental value. The reaction $H_2^+ + H_2 \rightarrow H_3^+ + H$ will take place with at most a small amount of kinetic energy. The difficult three center integrals for the repulsions between pairs of electrons were calculated explicitly in ellipsoidal coordinates without the use of infinite series.

16. Cross Section for the Production of Triples. JOHN A. WHEELER, *University of North Carolina.*—Besides producing pairs in the neighborhood of atomic nuclei, energetic quanta should create positrons and electrons in the fields of the outer electrons. As pointed out by Perrin[1] who originally suggested the possibility of this effect, the low energy limit is not $2mc^2$, as in ordinary pair production, but at $4mc^2$ (2.04 MEV), because of the energy imparted to the electron in whose neighborhood the pair is produced. Indeed, the relations for the final momenta and energies are symmetric in the original electron and the two new ones, and determine a lower bound for the energy of any one of the three. The cross section for the process is calculated by taking account of the symmetry between the original electron and the newly created one. Because of the relativistic velocities, Moller's retarded interaction is used. Detailed probability studies on the effect in a cloud chamber should give a new test of the relativistic interaction between two electrons at high energies. The production of triples may be expected to be of considerable importance in the absorption of high energy quanta in substances of such low atomic number as water and air.

[1] Perrin, Comptes rendus 197, 1100 (1933).

17. The Infrared Absorption of Mixtures of Water and Acetone. E. K. PLYLER AND DUDLEY WILLIAMS, *University of North Carolina.*—A study of the infrared absorption spectra of absolute acetone and acetone containing water showed bands of solvation in the regions of 1.6μ and 2.7μ. The band at 2.7μ was studied for concentrations of water in the acetone of 0.5 percent to 70 percent. The intensity of the solvation band increased with the water content. When the water content was large, the 3μ water band overlapped the solvation band. Absorption spectra were obtained for ten mixtures. It was found that water with concentrations as low as 0.1 percent in the acetone could be detected by the presence of this band.

18. Infrared Absorption of Cyanides, Thiocyanates, and Their Isomers. DUDLEY WILLIAMS, *University of North Carolina.* (*Introduced by E. K. Plyler.*)—Aqueous solutions of inorganic cyanides have been studied in the region from 1.2μ to 7.5μ. In all the materials a characteristic absorption band was observed in the region from 4.38μ to 4.90μ. The exact position of the band was found to be different for the various substances. Bands in this same region were observed for several organic cyanides. This characteristic absorption was attributed to changes in the vibrational energy of the bound CN group. The organic cyanides and thiocyanates furnish an opportunity for a study of the effects of isomerism on infrared absorption. Six organic liquids and their isomers were studied. The bands characteristic of the NC group are of much greater intensity and appear at slightly longer wave-lengths than the corresponding CN bands.

SATURDAY MORNING AT 10:00 O'CLOCK

Chemistry Building, Room 1

19. Columnar Ionization. W. R. KANNE, *The Johns Hopkins University.*—A study has been made of the ionization current produced by alpha-particles as a function of the angle between the path of the particles and the electric field. A polonium source was mounted above a parallel plate ionization chamber so that it could be rotated about an axis lying in the lower surface of the upper plate and passing through the fine hole in this plate which admitted the particles to the chamber. The lower plate, which served as the collecting electrode, was surrounded

by a large guard ring and connected to the grid of an FP–54 vacuum tube. It has been found that the increase in ionization current is linear with respect to the angle between the path of the particle and the field. No deviation from linearity occurs as the path and the direction of the field become parallel. The slope of the curves becomes slightly less as the field strength is increased. The slopes are correspondingly larger for the curves run at two atmospheres than for those run at one atmosphere. For a field of 100 volts per cm and one atmosphere pressure, the number of ions collected changes about 3 percent as the angle changes from 0° to 10°.

20. Theoretical Considerations Concerning Passage of Electrons Through Magnetized Iron. W. F. G. SWANN, *Bartol Research Foundation of the Franklin Institute.*—On the Lorentzian theory the magnetic induction, B, is the average value of the true magnetic field H, averaged throughout the magnetic material. In this average, regions inside the magnetic entities responsible for the polarization make contributions which determine the whole difference between B and the ordinary microscopically defined field, h, equal to $B-4\pi I$. A study is made of the special case where the entities are rotating electrical spheres. If the entities are very small in volume the chance of an electron missing all of them in its passage through a reasonably small length of the magnetized material is considerable. For such electrons as miss the entities the effective deflecting force is determined on the average by $h+2\pi I$. The true average for all electrons passing through the material is determined by $B=h+4\pi I$; but, that average is contributed to in appreciable amount by very few electrons which experience deflections much in excess of those determined by B. These considerations have important consequences in relation to the interpretation of experimental results.

21. Deflection of Cosmic-Ray Secondaries by Magnetized Iron. W. E. DANFORTH AND W. F. G. SWANN, *Bartol Research Foundation of the Franklin Institute.*—At a previous meeting we described experiments using Geiger-Müller counters which showed that the cosmic-ray electrons experience a definite deflection when they pass through a magnetized iron core in a direction normal to the magnetization. The more recent appearance of appropriate energy distribution data, as found in a counter controlled Wilson chamber by Anderson and Neddermeyer, enables us to arrive at a more satisfactory interpretation than was possible at that time. We have also been able to set limits to the correction necessitated by the presence of cosmic-ray showers. By taking the various probable errors into account it appears that the experimental results may be accounted for by assigning a value for the effective magnetic vector somewhere between the induction B and $B/3$. The assignment of a value different from B involves no logical difficulties if one allows that the deflections of a number of electrons of the same energy have a statistical distribution. For, although the arithmetic average of the deflections must be determined by B, the effect observed in the counter experiment corresponds to a different sort of average.

22. The Absorption of Cosmic-Ray Electrons at 10,600 Ft. and at Sea Level. R. H. WOODWARD AND J. C. STREET, *Harvard University.*—Counter measurements of the absorption of cosmic-ray electrons have been made at Echo Lake, Colorado, elevation 10,600 ft. Care has been taken to obtain results directly comparable with those previously found at sea level.[1] For this purpose the same counters and geometrical arrangement were used and the efficiencies were measured at each station. The results are sufficiently precise to permit a comparison of the quality and intensity of the radiation at the two elevations. The following abbreviated table illustrates the comparison.

THICKNESS OF LEAD ABSORBER (cm)	COUNTS PER MIN. AT ECHO LAKE (52.5 cm)	COUNTS PER MIN. AT CAMBRIDGE (76 cm)
0	0.540	0.289
15.2	.284	.209
91.5	.132	.107

The atmospheric layer between the two elevations is equivalent to 36.3 cm of lead on the extranuclear electron scale.

[1] Street, Woodward and Stevenson, Phys. Rev. **47**, 891 (1935).

23. Effect of Rainfall on Ionization Registered by Recording Cosmic Meter with Top Shield Removed. RICHARD L. DOAN, *University of Chicago.*—Several recording cosmic-ray meters operated with bottom shielding only have shown pronounced increases of ionization during thunderstorm periods. Investigation has shown these increases to be associated with rainfall and not with atmospheric electrical discharges. The excess ionization starts at the beginning of the rain and continues for an hour or more after the precipitation has stopped, thus indicating an appreciable life for the responsible ionizing agent. Simultaneous tests with two meters, one with no top shield and the other shielded from above with 1 cm of lead, indicate an absorption coefficient for the radiation about equal to that of gamma-rays, from which it is concluded that the effect is largely due to Ra B and Ra C brought down with the raindrops from the upper atmosphere. The radioactivity of freshly fallen rain was first observed by C. T. R. Wilson in 1902 and the effect reported here is doubtless of a similar nature. Such rapid changes in atmospheric radiation emphasize the importance of using heavy shields in making cosmic-ray observations.

24. Magnetic Spectrum of Positrons Generated in Lead by Th C″ Gamma-Rays. G. L. LOCHER AND C. L. HAINES, *Bartol Research Foundation of the Franklin Institute.*—A special beta-ray spectrograph has been constructed for simultaneous analysis of the energies of positrons and electrons generated in a centrally located metal foil. A collimated beam of γ-rays from 1.7 mg (Ra γ-ray equivalent) of $MsTh_1$, filtered through 1 cm of lead, was used for generating positron-electron pairs in a lead foil 0.02 cm thick (0.227 g/cm²). The magnetic field, as measured with a Cotton balance, is 503.0 ± 2.0 gauss. Two exposures: 39 days, with a wide source, and 47 days, with a narrower source, respectively, made with the lead generator, gave nearly identical results. The positrons showed a sharp cut-off at $(1.10\pm0.01)\times10^6$ ev ($H\rho=5098$); below this energy, the blackening was continuous. The cut-off is, thus,

approximately 500,000 volts lower than the predicted maximum energy for positrons generated in this way. The blackening of the films by negative electrons was continuous up to the energy-limit of the spectrograph. Double emulsion film (Eastman x-ray film) was used; the blackening of each emulsion by positrons and the γ-rays emitted by their annihilation was measured with a microdensitometer. The upper emulsions showed distributions of blackening, on the positron side, similar to those of the lower emulsions, but of lower density. A similar spectrogram, with silver as the generating element, is now being made; the results of this exposure will be available for the meeting.

25. Experiments on Slow Neutrons with Velocity Selector. J. R. DUNNING, G. A. FINK, G. B. PEGRAM AND E. SEGRÈ, *Columbia University.*—Further experiments with the mechanical velocity selector for slow neutrons at room temperature are in agreement with previous results.[1] Considerations of the form of the experimental curve to be expected if the neutrons were in thermal equilibrium within the paraffin with a Maxwellian distribution of velocities, show that within the limits of precision, the experimental results follow this curve. The resolution and precision at present are not sufficient to detect small departures from a Maxwellian curve. Attempts to measure differences in the absorption of Cd with neutrons selected from the upper and lower parts of the distribution curve have not shown any departures beyond experimental error. The velocity distribution of "cold" neutrons at about 95°K was studied by cooling with liquid air 2000 cc of paraffin contained in a soft glass Dewar, the source being at the center of the paraffin. The number of very slow neutrons is increased, and the maximum of the distribution curve shifted toward lower velocities, as is to be expected.

[1] Phys. Rev. **48**, 704 (1935).

26. Absorption of Neutrons with Lithium and Boron as Detectors. D. P. MITCHELL, J. R. DUNNING AND G. B. PEGRAM, *Columbia University.*—A comparison of Li- and B-lined ionization chambers used as detectors in measuring the transmission of slow neutrons through various substances has been made and absorption (capture plus scattering) with varying thickness has been measured. The cross section of B, Li and Cd measured with similarly constructed Li chambers differed a little more than the statistical error. Measurements with a boron chamber agreed with those from one of the lithium chambers within the statistical error. To test the effect of thickness and surface condition of the Li, chambers having different fronts were compared by measuring the absorption of cadmium. Variations with thickness are insignificant, but the ratio of fast to slow neutrons detected increases when the Li is permitted to oxidize and absorb water vapor. This may be due to the projection of H nuclei and the absorption of the disintegration particles from within the Li by the oxide on its surface.

27. Production and Absorption of Slow Neutrons in Hydrogenic Materials. G. A. FINK, J. R. DUNNING, G. B. PEGRAM AND E. SEGRÈ, *Columbia University.*—A Rn-Be neutron source was placed at the center of several sizes of cylinders containing water and the number of neutrons emerging per minute determined by the use of an 8-cm diameter Li-lined chamber and an amplifier-recorder system. The relation between the number of slow neutrons counted and the thickness of the water layer outside of a Cd shell placed in the water shows rates of production and absorption as in our previous measurements on paraffin spheres of diameters from 4 to 45 cm. From the rate of absorption and the known M.F.P. in paraffin the mean life time of a neutron in paraffin is computed to be of the order of 10^{-4} sec. The number of slow neutrons coming from various zones of the end of a paraffin cylinder 16.6 cm diameter and 22 cm long was counted and the relative number/cm^2/min. found to decrease from 1 in central (5.1 cm diam.) to 0.7 for the intermediate (5.1–10.6) and 0.25 for the outside (10.6–16.6) zone, with an average of 0.45 for the whole end surface. The number of fast neutrons not absorbed by Cd is, on the same basis, 0.06.

SATURDAY AFTERNOON AT 2:00 O'CLOCK

Chemistry Building, Room 1

28. Excitation Potential of $K\alpha$ X-Ray Satellite Lines. LYMAN G. PARRATT, *National Research Fellow, Cornell University.*—With a two-crystal vacuum spectrometer the curve of the intensity of $K\alpha$ satellite lines *vs.* voltage of the x-ray tube has been determined for the $K\alpha_{3,4}$ lines of titanium. For voltages greater than 11 kv the satellite intensity (total area of the $K\alpha_{3,4}$ satellite structure) relative to the intensity of the $K\alpha_1$ line is 2.21 percent; the ratio of peak intensities α_4/α_1 is 0.69 percent. The measured excitation potential of the Ti $K\alpha_{3,4}$ lines is 5450 ± 100 volts, 500 volts in excess of the excitation potential of the $K\alpha_{1,2}$ lines. Assuming 0.85 as the screening constant of a missing K electron on an L electron, one calculates that the voltage required to produce a state of KL ionization in the titanium atom is 5455 volts. This value is in excellent agreement with the measured excitation potential and the conclusions of the experiments are in support of the Wentzel-Druyvesteyn theory of the origin of the $K\alpha_{3,4}$ satellite lines.

29. Practical Analysis by Use of X-Ray Diffraction. J. D. HANAWALT AND H. W. RINN, *The Dow Chemical Company, Midland, Michigan.*—The x-ray diffraction of a crystalline substance provides a practical method of chemical analysis because the diffraction pattern can be used empirically as a unique identification of a substance

without any necessity of a theoretical interpretation of the pattern. In the course of a few years of use of x-ray diffraction as a supplement to chemical analysis, the patterns of about one thousand substances have been accumulated. A suitable system of classification of these films makes it possible to use them for crystalline substances in an analogous way to that in which finger prints are used to identify persons. The system of classification which has been adopted allows a pattern to be identified in less than a minute if it is contained in the portfolio of standard patterns. Some improvements in the technique of obtaining good patterns will also be described.

30. The Structure of Ice II. RONALD L. MCFARLAN, *Harvard University.*—The stability of the high pressure ice forms discovered by Tammann and Bridgman at very low temperatures and atmospheric pressure has made it possible to obtain x-ray powder diffraction photographs of these forms. The experimental procedure is very briefly discussed. An analysis of the ice II diffraction patterns leads to a side-centered orthorhombic cell with $a=7.80$A, $b=4.50$A, and $c=5.56$A. This cell contains eight molecules, has the symmetry of space group V^5-C222_1, and gives a value for the density of 1.21. The proposed arrangement of the hydrogen atoms indicates that the transition from ice I to ice II breaks up the water molecule, and that ice II is an ionic crystal. According to the model described the effect of a pressure of 2100 atmospheres in forming ice II is (1) to decrease the packing volume of the oxygen ion approximately three percent; (2) to break down the open ice I structure by a slipping of the oxygen ion layers relative to each other; (3) to give a four-coordinated structure where each oxygen is surrounded by a badly distorted tetrahedron of oxygen ions.

31. The Structure of the Sulphur Molecule by Electron Diffraction. LOUIS R. MAXWELL, S. B. HENDRICKS AND V. M. MOSLEY, *Bureau of Chemistry and Soils, Washington, D. C.*—Considerable uncertainty exists as to the structure of the S_2 molecule, band spectra values obtained by different authors for the nuclear separation in the normal state ranging from 1.60 to 1.84A. Independent determinations of this distance can be made by means of electron diffraction. A gas boiler containing iron pyrite heated to about 850°C provided a source of hot sulphur vapor calculated to give a very predominant concentration of S_2 molecules. The electron diffraction pattern obtained from this gas showed two outer rings classified as the third and fourth maxima located at $(1/\lambda)\sin\frac{1}{2}\theta=0.827\pm0.008$ and 1.09 ± 0.02, respectively; the inner rings appeared only as halos. Assuming a diatomic structure the two outer rings give a S−S distance of 1.95 ± 0.05A, a distance definitely greater than any of the band spectra values. When the temperature of the boiler is lowered the interference pattern is changed. A prominent second ring comes at $(1/\lambda)\sin\frac{1}{2}\theta=0.516\pm0.005$ while the third maximum has a diameter of 0.790 ± 0.008. This pattern can be satisfactorily explained by the formation in the vapor of S_3 or S_{3+n} molecules where $n=1, 2, \cdots$, with the S−S−S valence angle approximately 100° and the S−S distance between neighboring molecules as 2.10A, entirely consistent with similar constants found from crystal structure data.

32. The Electron Distribution in $(NH_4)_2C_2O_4\cdot H_2O$ and the Structure of the Oxalate Group. S. B. HENDRICKS AND M. E. JEFFERSON, *Bureau of Chemistry and Soils, Washington, D. C.*—The electron distribution of the orthorhombic crystal $(NH_4)_2C_2O_4\cdot H_2O$ projected on (001) was obtained by a Fourier analysis making use of quantitative intensity measurements for (*hko*). This analysis combined with a determination of the atomic parameters perpendicular to (001) gave the complete structure. Separations of covalently linked atoms in the $C_2O_4^{--}$ group are C−C, 1.581 ± 0.01A, C−O, 1.25 ± 0.02A, and C−O, 1.23 ± 0.02A with the angle $O-C-O=129°\pm2°$. In this compound the O−C−O parts of an oxalate group are in planes at an angle of 28° while in $H_2C_2O_4\cdot 2H_2O$, α and β $H_2C_2O_4$ the parts are coplanar.

33. The Anisotropic Growth of Silver Crystals by Condensation from Vapor. JOSEPH H. HOWEY,* *Yale University.*—It has been found that silver vapor condensing in a vacuum on suitable nuclei of solid silver maintained at a temperature just below the melting point forms single crystal needles under certain conditions. The observed habit of growth is probably dependent upon the presence of certain impurities but it is noteworthy that a metal having face-centered cubical symmetry in the solid state should ever condense in the form of needles. The longest needles grown have been about three millimeters long and several tenths of a millimeter in diameter. At least five percent of the needles have abrupt changes in direction, the appearance of which indicates that the boundary between the two linear portions coincides closely with a single crystallographic plane extending across the entire cross section. Abrupt changes in direction both less and greater than 90° have been observed but no branching has been found. One tentative explanation of the growth of these needles is to consider their occurrence as experimental evidence for the idea that the forces between metal atoms in a crystal may be greater in one direction than in others which are crystallographically identical and that the direction of this anisotropy may be constant throughout a domain of considerable size. The existence of such anisotropy would serve to explain the growth of the needles regardless of whether the growth is conditioned by the presence of impurities or not.

* Now at Georgia School of Technology.

34. The Production of Large Single Crystals of Lithium Fluoride. DONALD C. STOCKBARGER, *Massachusetts Institute of Technology.*—Preliminary experiments performed to determine the conditions under which lithium fluoride could be crystallized continuously from the melt indicated that high purity of the salt and steep temperature gradient normal to the freezing layer were important. Accordingly an improved method of synthesizing salt, and a special double furnace, in which the required gradient can be maintained without overheating the melt or chilling the crystal, have been developed. With the aid of these im-

provements lithium fluoride crystals of excellent optical quality up to three inches in diameter are now being grown regularly. These possess such stability that they can ordinarily be sawed and ground to any desired shape.

35. A Laboratory Induction Pump for Mercury. E. S. GILFILLAN, JR., *National Research Fellow*, AND S. M. MACNEILLE, *Massachusetts Institute of Technology*. (*Introduced by J. C. Boyce.*)—Difficulties were encountered with reciprocating pumps for the continuous circulation of mercury. An all-metal pump, without moving parts, operating on the principle of a polyphase induction motor was developed. The mercury flows in the annular region between two concentric tubes. Surrounding the tubes are coils connected to a polyphase supply. The result is a series of magnetic ripples travelling along the axis of the tubes which drag the mercury along by virtue of the currents induced in it. Lifts in excess of a meter and capacities in excess of 50 cc per second have been obtained. Comparison will be made with the designs of previous investigators.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for only at the session indicated.

36. Deflection and Focusing of a Beam of Hydrogen Atoms. I. I. RABI, J. R. ZACHARIAS AND J. M. B. KELLOGG. *Columbia University.*—A beam of hydrogen atoms in the normal $^2S_{\frac{1}{2}}$ state was deflected in a weak inhomogeneous magnetic field. It was then passed through a strong field arranged to produce deflections opposite in direction to those of the weak field. With nuclear spin I, the intensity measured at the undeflected position of the beam should show $2I+1$ peaks when plotted as a function of the first deflecting field. These peaks correspond to focusing by the strong field of the $2I+1$ magnetic states of the atoms in the weak field. From the values of H at these peaks it is possible to calculate the hfs separation for the state irrespective of the velocity distribution of the atoms in the beam. The hydrogen atoms were produced in a Wood discharge tube designed to yield a high ratio of atoms to molecules in the beam. The deflecting fields are of the type previously described. Detection was effected by means of a Pirani gauge. The intensity curve shows two well-defined peaks which gives a value of the spin of the proton of $\frac{1}{2}$, corroborating the result obtained by alternating intensities in band spectra. Further experiments to determine accurately the hfs separation are in progress.

(To be called for after Paper No. 18.)

37. The Photoelectric Work Function of Ca and Photo Emission from Non-Homogeneous Surfaces. N. C. JAMISON AND R. J. CASHMAN, *Northwestern University.*—Using Fowler's method, the photoelectric work function of Ca was determined for layers produced by single distillations, using a multiple reflection cell adapted to the study of the variation of work function with temperature. Data in good agreement with Fowler's theory were obtained. The room temperature work function by Fowler's method was 2.704 volts; the greatest variation from the mean of seven determinations was .004 volt. After repeatedly heating the surface to approximately 100°C the data did not agree with Fowler's theoretical curve. The departures from the theoretical curve were consistent with the assumption that, after heating, the surface was not homogeneous. Analysis of the data gave evidence of two emitting surfaces, one assumed to be Ca having a work function of 2.704 volts and the other having a work function some .2 volt lower. It is concluded that a single distillation cell is not suited to the accurate determination of the temperature coefficient of the work function; also a multiple reflection cell is not desirable. When working with composite surfaces having emitting areas of nearly the same work function, the data will not fit Fowler's theoretical curve.

(To be called for after Paper No. 10.)